Photovoltaic Manufacturing Technology

PVMaT Fact Sheet

Automated Cell Assembly Research

Spire Corporation participated in Phase 3A of PVMaT.

PVMaT is a 5-year, cost-shared partnership between the U.S. Department of Energy and the U.S. PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.

Spire Corporation

Goals

The overall goal of Spire Corporation under the PVMaT Project has been to reduce PV costs by developing high-throughput (5 MW per year), automated processes for interconnecting thin (200-micrometer [µm]) silicon solar cells. Significantly more 200-µm wafers can be produced from a silicon ingot than conventional 350- to 400-µm wafers, thus reducing cell cost; but, an unacceptably high breakage rate in processing normally makes such thin cells impractical. In this program, Spire achieved high yields with these fragile cells by developing processes that reduce mechanical and thermal stresses. Other benefits are increased use of automation and higher process throughput. A complete, automated processing system is now offered as a commercial product to PV manufacturers.

Spire's SPI-ASSEMBLER™ 5000 automated solar-cell assembler.

The broad PVMaT project was intended to improve PV product quality, accelerate production scaleup, and substantially reduce manufacturing costs. Spire's program, now completed, improved process control, yield, throughput, material utilization efficiency, and automation, and thus achieved reduced module manufacturing costs and improved products.

Technology

Previous methods of interconnecting solar cells were limited to throughput of about 8 seconds per cell and were not able to process thin (e.g., 200-µm) cells with acceptable yields. Two separate soldering processes were used for each cell—one for the front contact and another for the back contact, each with the potential for yield loss due to cell heating. This also required a significant amount of labor to manually load cells into alignment fixtures to prepare for back-surface soldering.

Results

In this program, Spire developed a fully automated solar-cell assembly system for processing standard and thin solar cells. The materials loaded into the system are stacks of cells, reels of solder-coated copper interconnect ribbon, and liquid soldering flux. The system produces multiple rows of cell strings, where each string comprises a number of cells soldered together in series. Spire also developed automated processes for cell loading, cell aligning, ribbon handling, fluxing, ribbon-to-cell soldering, cell string handling, and string current-voltage testing.

Spire uses flexible automation techniques wherever practical to enable the production of a variety of module designs with minimal mechanical adjustments or tooling changes. This flexibility is provided through software control of the tab length, the tab stress-relief bend location, the soldering cycle, the number of cells per strings, the number of strings per module, and the arrangement of strings in a series, parallel, or combined configuration.

Spire teamed with ASE Americas and Solec International, who manufacture PV cells and modules, and with automation specialists at the University of Massachusetts Lowell (UML). UML developed machine-vision software for cell alignment and inspection tasks. Solec produced thin cells for preliminary testing at Spire. And ASE Americas provides the test site for more system testing in a manufacturing setting.

Under this PVMaT Project, Spire developed new low-stress techniques, including

- Machine-vision-based cell alignment that eliminates mechanical handling of cell edges and provides an automated visual inspection for cracks, chips, misoriented (i.e., rotated or upside down) cells, and cell type
- A soldering process that uses conductive preheating to reduce thermal stress and high-intensity light to simultaneously solder metal interconnect leads to both sides of a solar cell in one step. The gentler heating and reduced number of heating steps improve yield while eliminating the handling needed to transfer and align tabbed cells—tasks required for separate front and back soldering.

Good pull strengths have been measured on both thin and standard-thickness cells. Failure during pull testing is typically at the cell's contact/silicon interface or in the bulk silicon, rather than at the solder-joint/contact interface.

Spire measured cell-to-cell cycle times of 3.8 to 4.0 seconds per cell, achieving the program goal of 4.0. Because the equipment has flexibility to adjust for a variety of cell parameters, stringing was successfully demonstrated on a variety of cell types, sizes, and contact configurations. In a separate task, the interconnect ribbons from each cell string are joined to bus ribbons, to electrically connect the cell string. Spire evaluated incorporating a bus ribbon bonding station with the assembler and determined that it was feasible to automate such a process using a pulse hot-bar reflow soldering technique.

A cost analysis was done to compare the cost of these new processes using a fully automated, a semi-automated, and a manual system. The costs—not including cells—were calculated to be $0.087/W (automated), $0.163/W (semi-automated), and $0.445/W (manual).

As a result of this program, Spire has a significant new product to offer the PV industry. Spire is marketing this system to the PV industry through technical reports, conference papers, sales literature, videotape of the system in operation, and visits to Spire for in-depth processing evaluations. Several systems based on the new processing technology developed under this PVMaT Program have already been sold to PV manufacturers.

Company Profile

Spire Corporation was founded in 1969 as a small R&D company studying high-energy physics. The company now occupies more than 6875 m^2 of manufacturing, laboratory, and office space in Bedford, Massachusetts. Spire began R&D in PV technologies in the mid-1970s and has been producing commercial equipment for manufacturing PV modules since 1981. The company's products include semiconductor materials and devices for optoelectronics applications, ion-beam processing services for medical components, and PV manufacturing equipment.

References

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For More Information

Ed Witt, NREL 303-384-6402

Richard King, DOE 202-586-1693

Doug Ruby, SNL 505-844-0317

Clay Aldrich, SEIA 202-383-2628

Michael J. Nowlan,
Spire Corporation 617-275-6000

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